# Introduction to GIS

*through Quantum GIS*

# Day 2: Technical Stuff Day

*offered by Valley Stewardship Network*

*taught and prepared by Legion GIS, LLC*

*March 2016*

# Today's Technical Stuff…

**Spatial Data**

--vector vs. raster

--common formats of each category

*(remember, this whole GIS thing is just data storage and interpretation)*

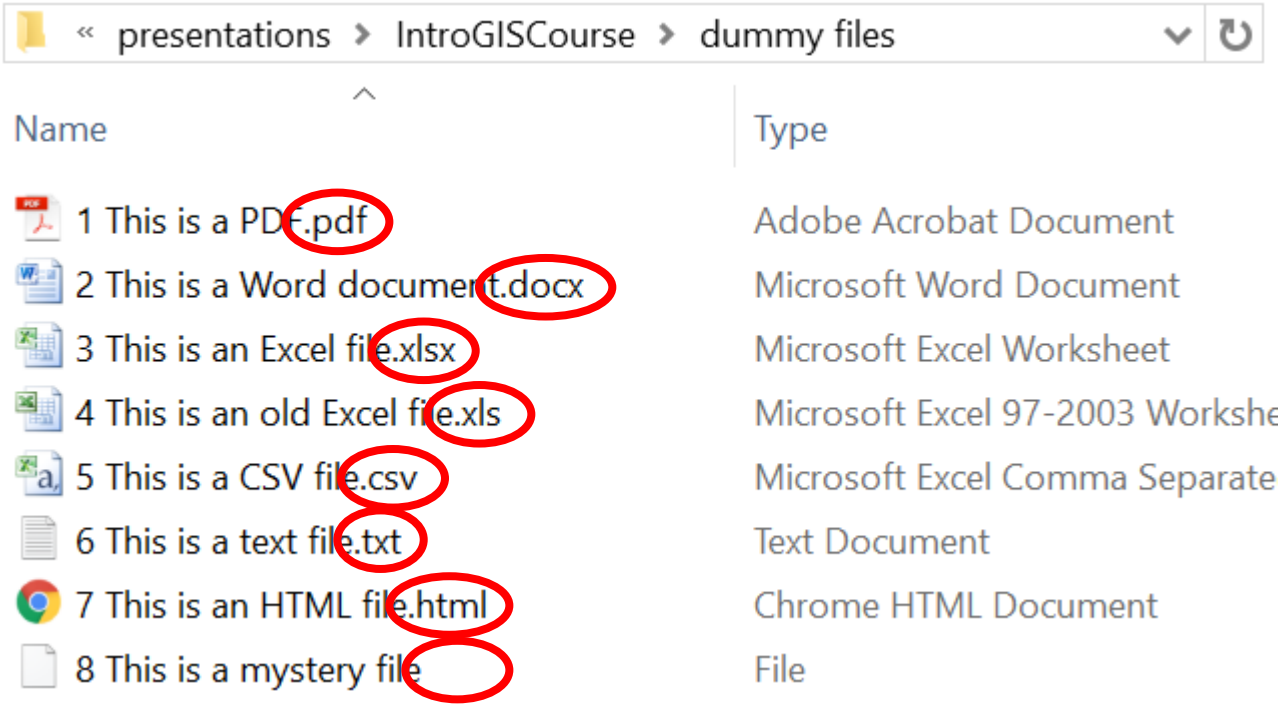
**Coordinate Reference Systems**

--needed to correctly interpret the spatial data

*(spatial data without a coordinate reference system is as misunderstood as a moody adolescent)*

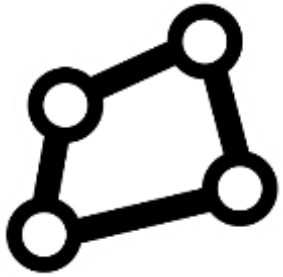
# Quick note on file extensions!

- File extensions are the part of the filename that tell your computer how to interpret the file, i.e. what program to use to open it.




- Again, GIS is basically data storage and interpretation.

# vector data



- Stored as discrete vector geometries, called "features"
- Three basic types of geometries: point, line, polygon
  - There are also more complex variations like "multipoint", or "multipolygon"
- An **attribute table** accompanies the geometries, with one row per feature
- The attribute table can have many columns (or "fields"), each containing a piece of information about the feature
- Use the Identify tool to quickly view all attributes for a given feature

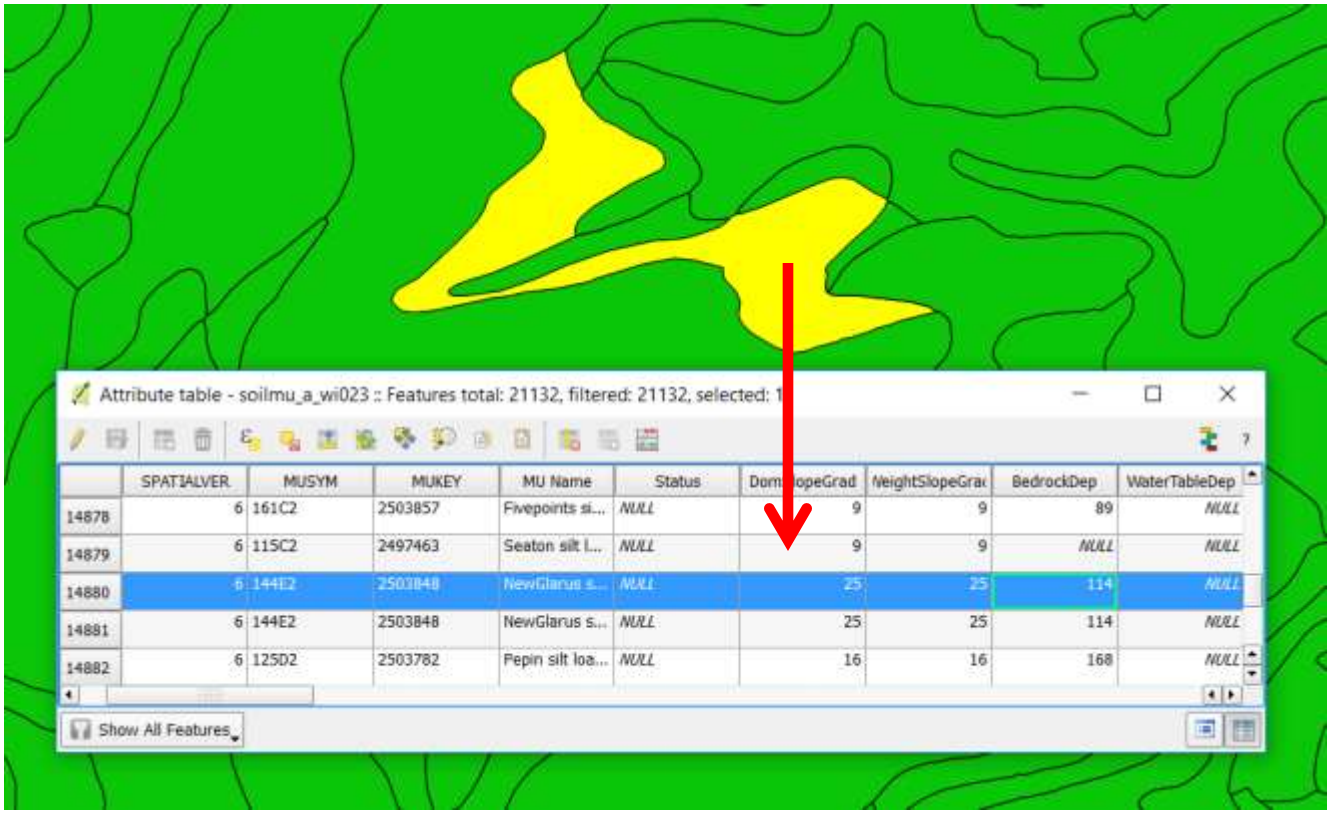
# example of vector data…

**the geometry**

(these are soil unit polygons)

**the attribute table**

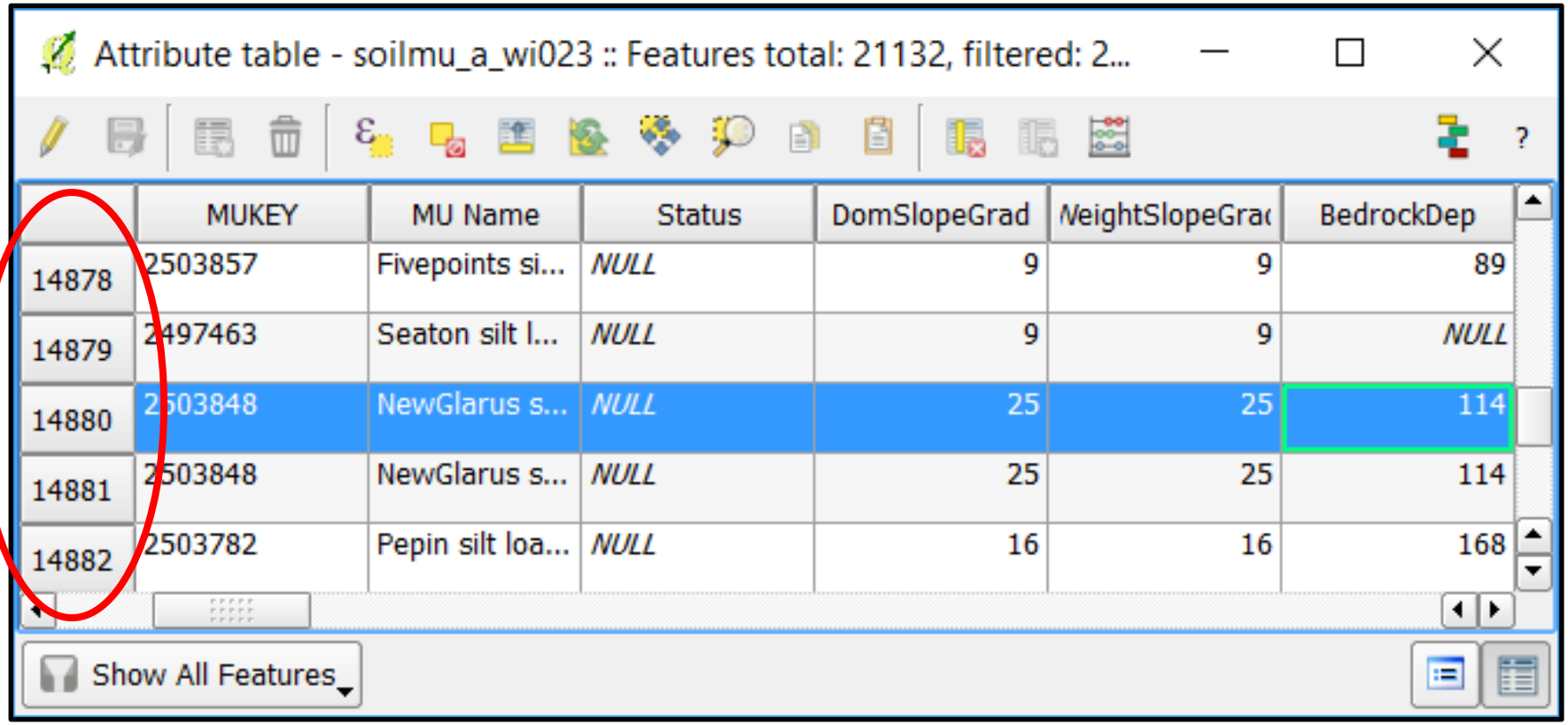
(these are attributes for each unit)




*USDA Soil Survey Geographic Database (SSURGO), Crawford County*

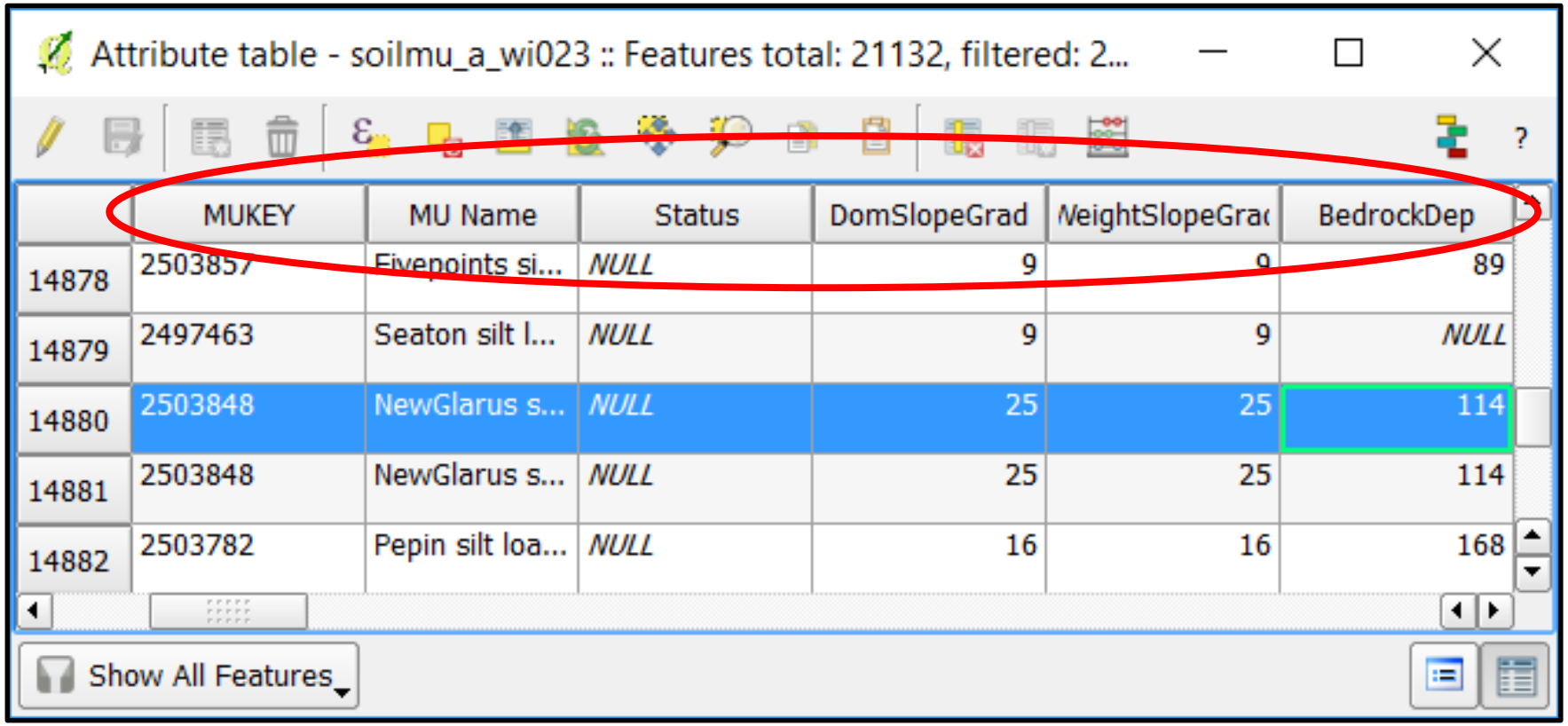
# a closer look at the attribute table…

– One row per feature, each row has an "object id"



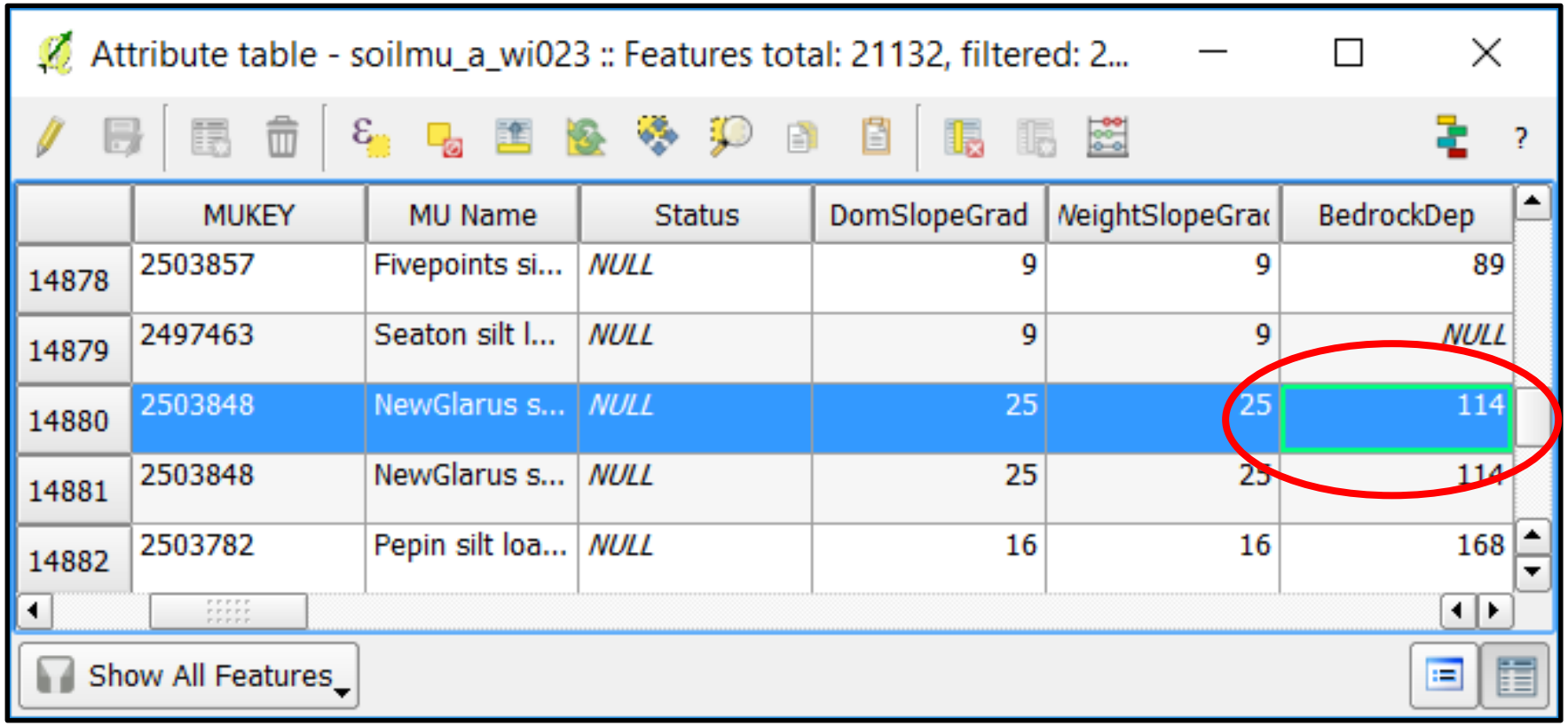
# a closer look at the attribute table…

– Multiple named columns (fields)



# a closer look at the attribute table…

– Here is the bedrock depth for this specific soil unit




| | MUKEY | MU Name | Status | DomSlopeGrad | WeightSlopeGrad | BedrockDep |
|---|---|---|---|---|---|---|
| 14878 | 2503857 | Fivepoints si... | NULL | 9 | 9 | 89 |
| 14879 | 2497463 | Seaton silt l... | NULL | 9 | 9 | NULL |
| 14880 | 2503848 | NewGlarus s... | NULL | 25 | 25 | 114 |
| 14881 | 2503848 | NewGlarus s... | NULL | 25 | 25 | 114 |
| 14882 | 2503782 | Pepin silt loa... | NULL | 16 | 16 | 168 |

# common vector formats

## ESRI Shapefile

- Most ubiquitous format (and open because ESRI published the specs a while ago)
- Has some technical limitations
  - 10 character field names, blah blah…
- Basically the best thing for us to use in QGIS right now
- A single shapefile is actually a combination of a few different files:
  - .shp (this holds the geometry, and is considered the main file)
  - .shx (this is a fancy indexing thing)
  - .dbf (this is the attribute table)
  - .sbn, .cpg, .prj, .qpg, .shp.xml (these may or may not be present, and contribute indexing, projection, metadata, or other information)
  - Mapping software like QGIS aggregates all these shapefile pieces into one dataset.

# common vector formats

## Delimited Text File

- Very simple text file that holds a table structure
- First line of the file holds the names of the table columns
- Each subsequent line holds information for one feature
- Easy to convert to spatial data if, for example, one column holds latitude coordinates and another holds longitude for each feature
  - We'll be doing this later!
- Often stored as a .csv file, or simply a .txt file
- If there are no coordinates, this is better considered "tabular data", not spatial data

# common vector formats

## ESRI File Geodatabase

- Currently, QGIS has read-only support for this format
- Holds vector data in "feature classes"
- NOT EXCLUSIVELY A VECTOR FORMAT: Can also hold an ESRI raster format, and annotation feature classes (independent labels)
- Can enforce "topology" rules—geometric relationships and/or constraints between feature classes

# raster data

- Information stored in cells (kind of like pixels)
- The "resolution" of a raster is defined by the real-world size of each cell
  - For example, in a 30 meter resolution raster each cell represents a square piece of the ground that is 30m x 30m
- Rasters are made up of "bands", each band has a single value for each cell
  - Elevation rasters have 1 band, which contains the elevation value of every cell.
  - Imagery rasters generally contain 3 bands, one each for red, green and blue. When displayed properly, this gives each cell an RGB value (color) to each cell
- Use the Identify tool to view the value for any cell in a raster

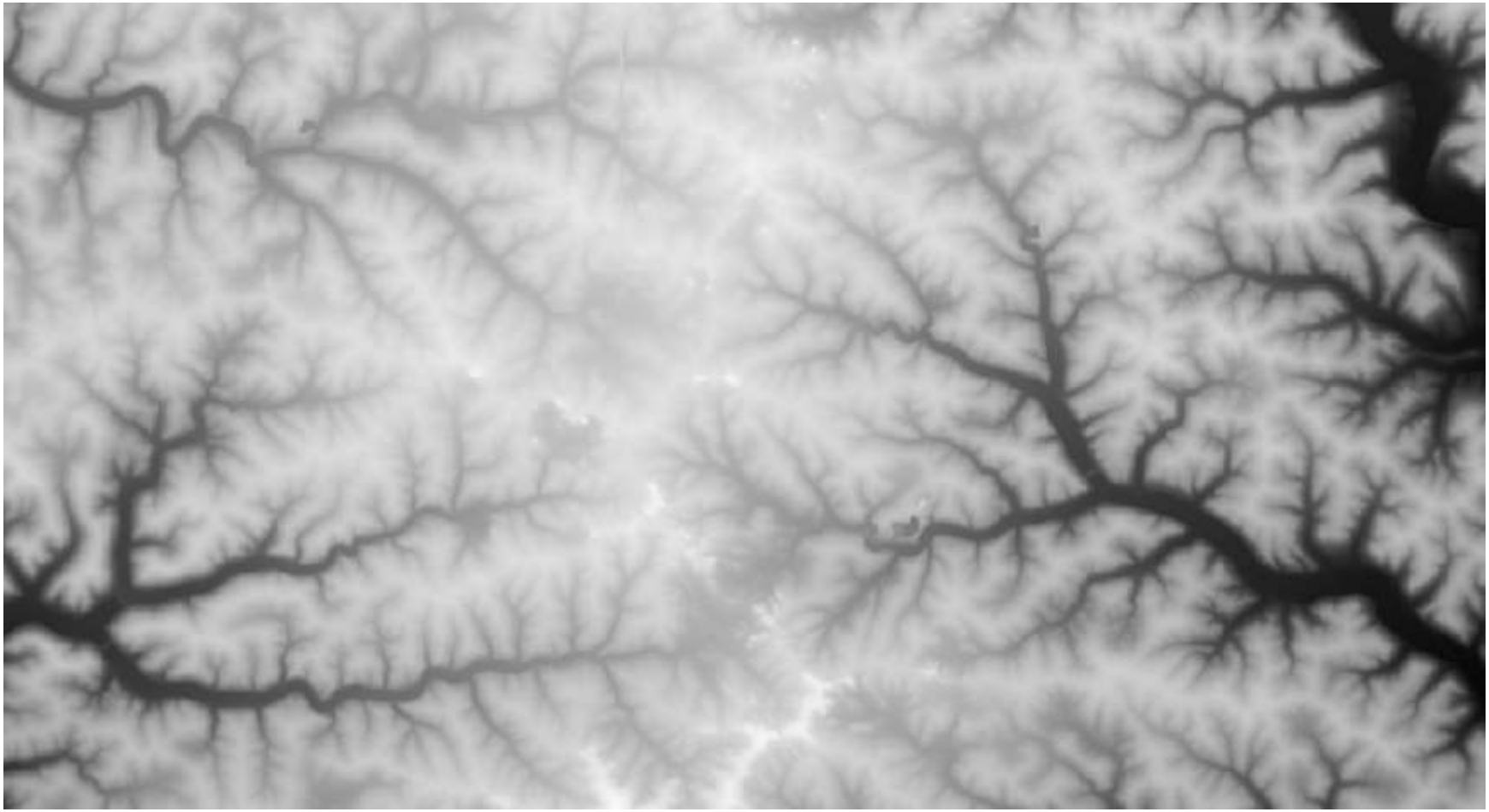
# raster data examples

## Aerial Imagery ("orthophotos" or "ortho imagery")

*MapQuest Aerial (displayed in QGIS as a Web Map Service via QuickMapServices plugin)*

# raster data examples

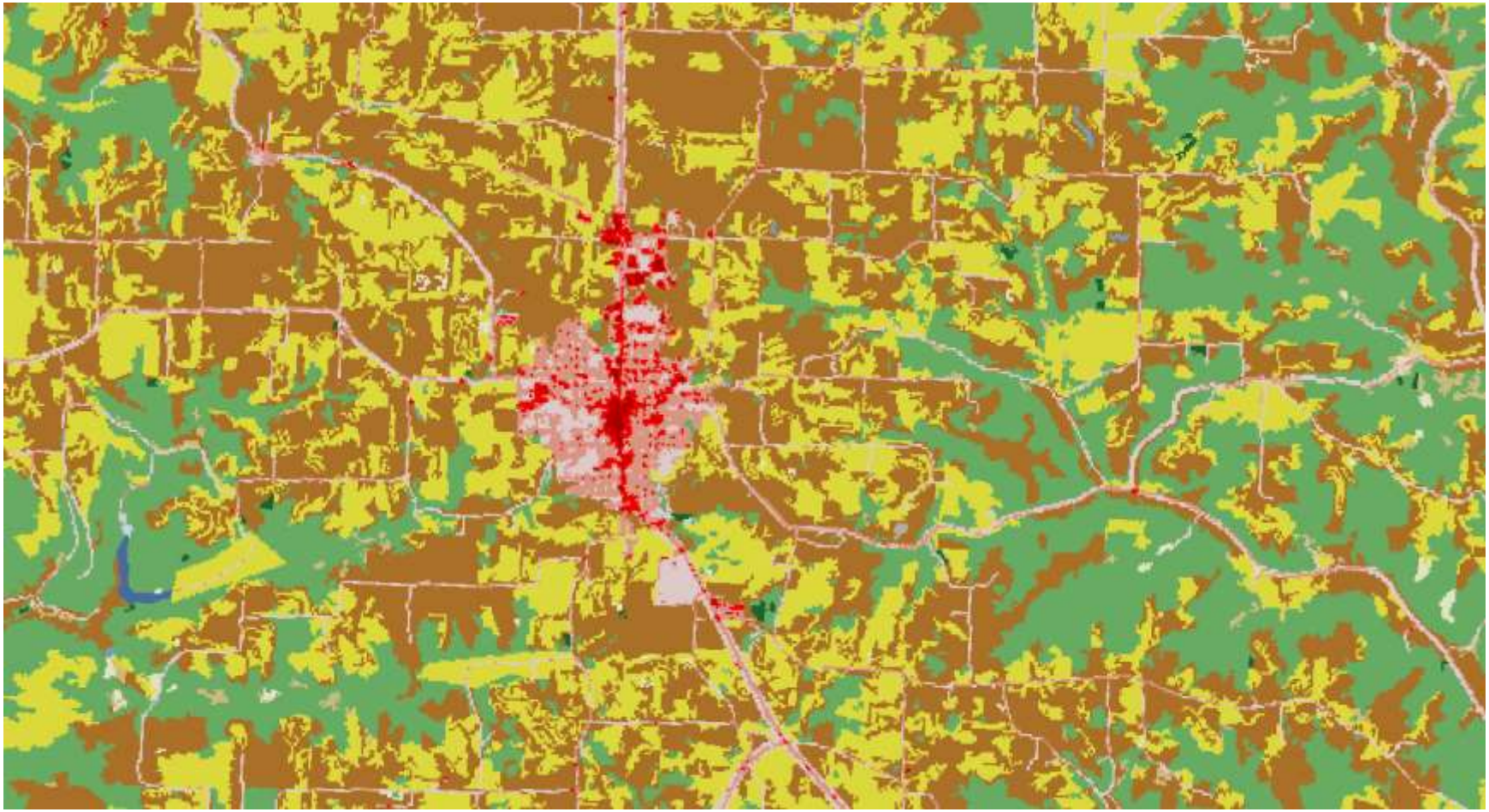
## Elevation ("continuous data")



*Vernon Co. 5ft LiDAR-derived Digital Elevation Model (found on WisconsinView)*

# raster data examples

## Land Cover ("discrete data")



*USDA National Land Cover Dataset (2011) acquired though NRCS Geospatial Data Gateway*

# common raster data formats

## TIFF, or GeoTIFF

- "Tagged Image File Format", .tif (or .tiff)
- Embedded spatial reference or an accompanying .tfw ("world file")
- Common for discrete, or "classified", data

## MrSID

- .sid, common for imagery

## ESRI ArcInfo Grid

- Comes in a folder named for the raster, with files inside. In QGIS you want the file called "hdr.adf".

## Image File

- .img, sometimes used for very large raster datasets

# just for a little more perspective…

**Wikipedia lists 18 different vector formats,**

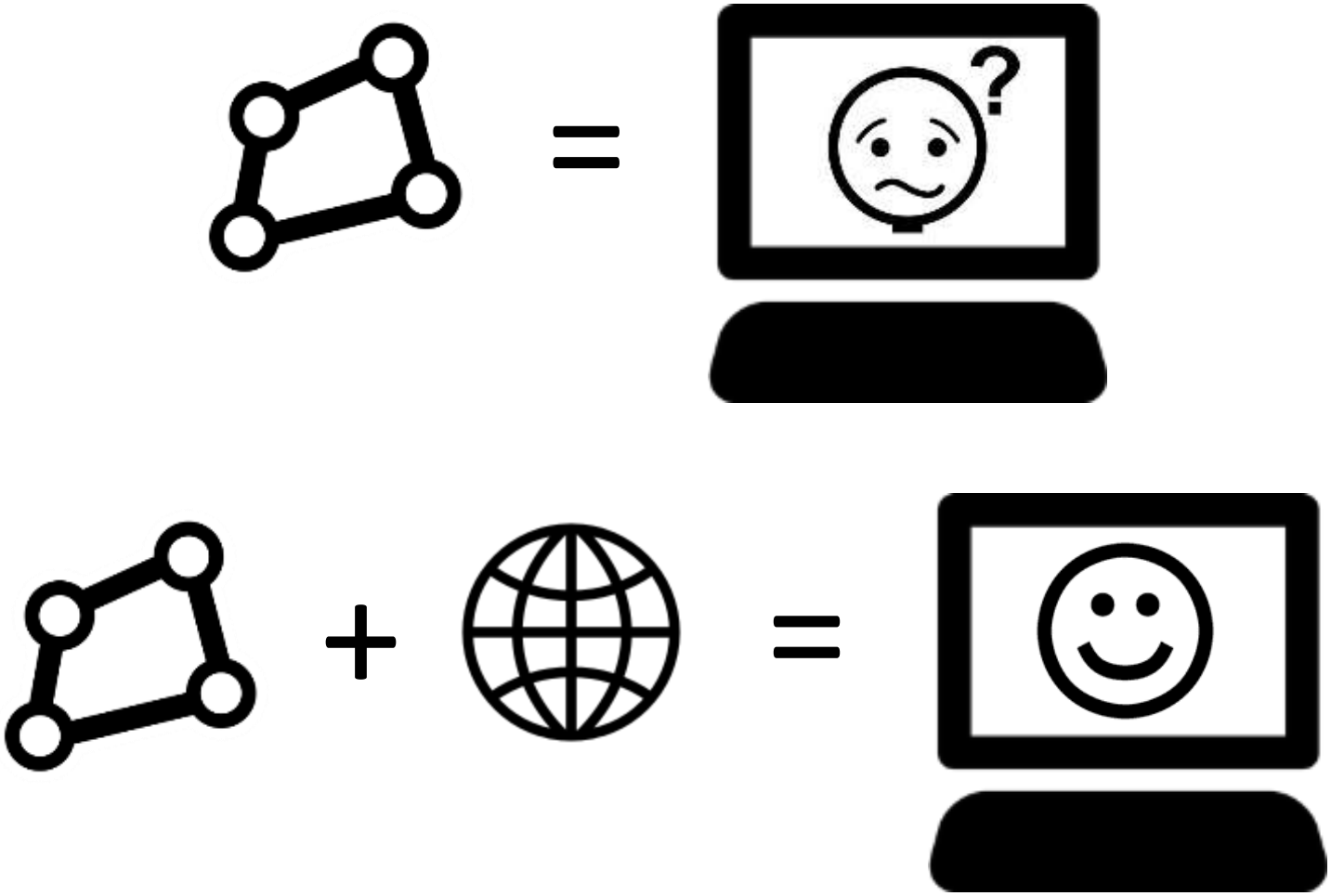
**and 13 raster formats. I don't know what most of them are.**

# coordinate reference system (CRS)

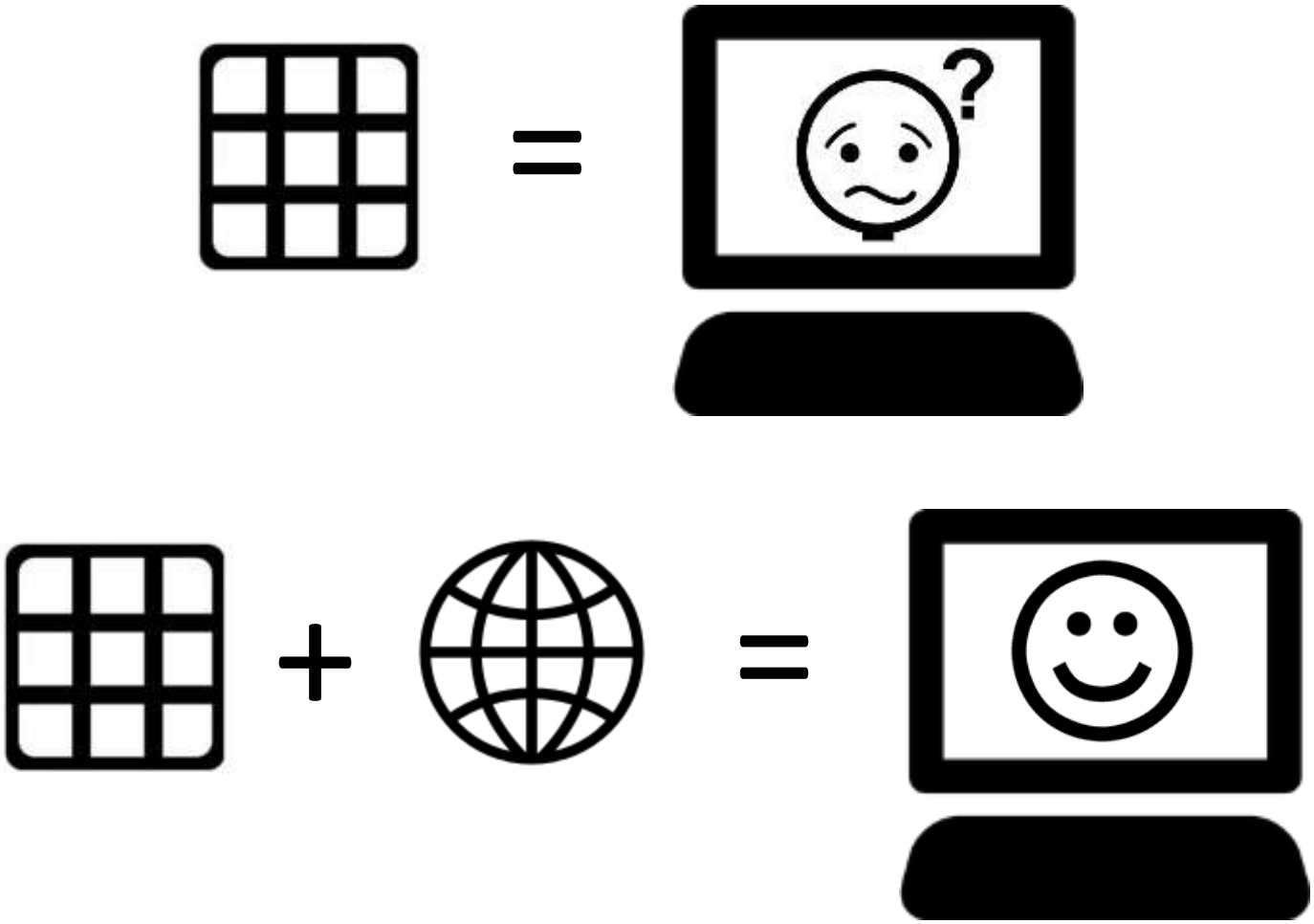
- More ways to refer to them:
  - spatial reference (SR)
  - spatial reference system (SRS)
  - projection (kind of a misnomer as you'll see)
  - We're going to stick with CRS, because that's what QGIS uses

- Where each spatial dataset is defined by its coordinates, a CRS is necessary to correctly interpret those coordinates.

# CRS tells the GIS how to interpret spatial data



# CRS tells the GIS how to interpret spatial data



# coordinate reference system (CRS)

- Hundreds of different CRS… but,
- They all fall into two categories
  - **Geographic Coordinate System (GCS)**
  - **Projected Coordinate System (PCS)**
- And they are all made from the same basic elements…

# elements of a CRS

First there is a datum…

…in fact, that's all you need for a **Geographic Coordinate System**.

Then a projection, an origin, and type of units are defined…

…and the result is a **Projected Coordinate System**.

datum

↓


+

projection,

origin,

units

↓

# elements of a CRS

First there is a datum…

datum

# what is a datum?

- An abstract model of the earth's surface, based on mathematical estimations of the earth's center and the dimensions/shape of the "spheroid"
- Latitude and longitude are degree measurements around this surface
  - Latitude is a North/South measurement
  - Longitude is an East/West measurement
- Let's consider these coordinates for a moment:

  N43° 33' 24" (latitude) and W90° 53' 21" (longitude)
- They actually mark *different* points on the earth depending on which datum you use to interpret them.

# to be more specific…

- We only really care about three "datums"
  - North American Datum 1927, better known as **NAD 27**
    - Developed in 1927, you can still find it on USGS topo maps sometimes
  - North American Datum 1983, better known as **NAD 83**
    - Defined in 1983, as with NAD27, optimized to model North America as accurately as possible
  - World Geodetic Survey 1984, better known as **WGS 84**
    - Defined in 1984, used for data collection worldwide
- Other notes:
  - GPS always collect coordinates in WGS84, but you can usually set them to convert those coordinates to NAD83 (or another datum) if you want.
  - The vast majority of all *continental* US spatial data uses NAD83, maybe NAD27
  - You'll also see HARN NAD83, which is a "statewide regional upgrade of NAD83" (from the NGS NOAA website)

# elements of a CRS

First there is a datum…

…in fact, that's all you need for a **Geographic Coordinate System**.

datum

# Geographic Coordinate System recap

- A GCS is needed to correctly interpret spatial data whose coordinates are stored as latitude and longitude
- A GCS is entirely based on a single datum
- There are only three GCS of which we need to be aware:
  - NAD27
  - NAD83
  - WGS84

# elements of a CRS

First there is a datum…

…in fact, that's all you need for a **Geographic Coordinate System**.

Then a projection, an origin, and type of units are defined…

datum

↓


+

projection,
origin,
units

# what is a projection?

- A mathematical formula to "flatten out" the globe in order to make a 2D map

- Popular projections you may have heard of…
  - Mercator
  - Well, I guess that's probably about it…

- Projections can get pretty wild. https://www.jasondavies.com/maps/transition/

# what is an origin?

- Just like in algebra, the bottom left corner of a Cartesian grid system
- It is defined by a "central meridian" and "latitude of origin" which are included in the CRS
- It is used to focus the projection on a specific area, often called a "zone", of the globe
  - This is because every projection can only faithfully show a certain portion of the globe (while greatly distorting the rest).

# what are units in a CRS?

- Usually just feet or meters.
- On the Cartesian coordinate system created by the projection, the units are the x,y measurements.
- Example coordinates:
  - 725249,95549
  - Which means X = 725,249 and Y = 95,549
  - Or 725,249 units EAST and 95,549 units NORTH of the origin.
    - And in this CRS, units happen to be **meters**.

# elements of a CRS

First there is a datum…

…in fact, that's all you need for a **Geographic Coordinate System**.

Then a projection, an origin, and type of units are defined…

…and the result is a **Projected Coordinate System**.

datum

↓


+

projection,

origin,

units

↓

# Projected Coordinate System recap

- Like a GCS, every PCS is based on a datum
- On top of the datum, a projection is used to create a 2D Cartesian plane, and an origin is used to focus the projection on a certain area
- Coordinates are an x,y position on the resulting Cartesian plane, and the units are measured in Feet or Meters (defined by the CRS itself)

# common PCS…

- UTM Zones (Universal Transverse Mercator )
  - CRS that uses UTM projection with either NAD27, NAD83, or WGS84 datum
  - All UTM CRS show specific zones

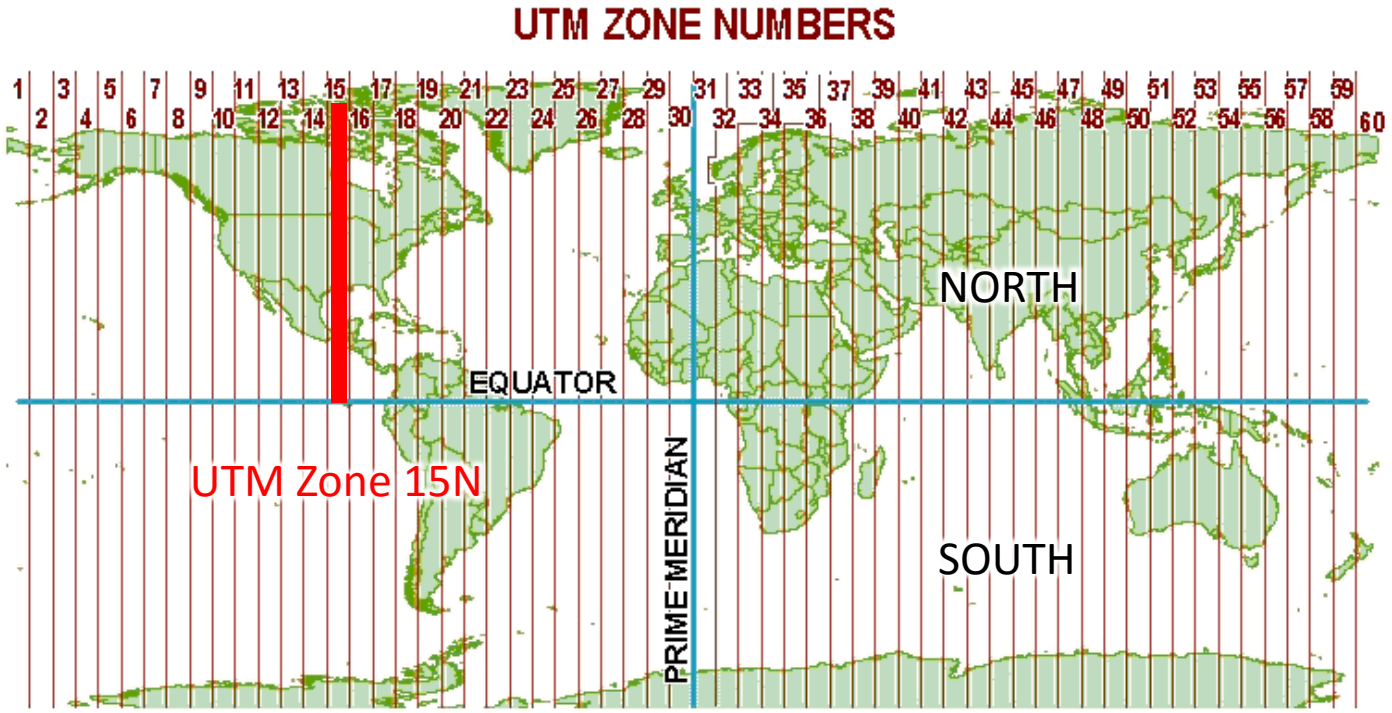



*Image from National Geospatial-Intelligence Agency website*

# UTM Zones in the continental US

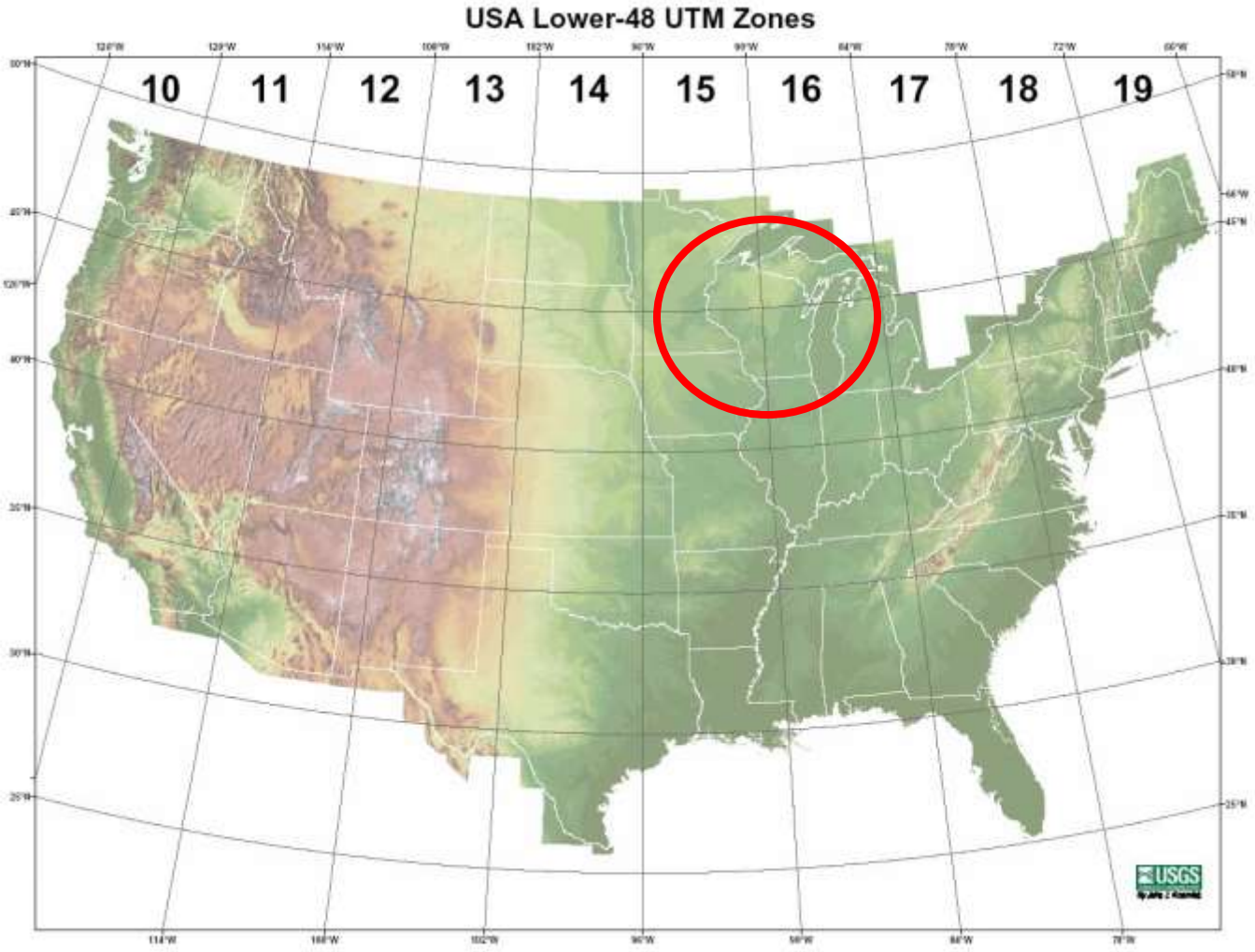



*Image from National Park Service*

# common PCS…

- State Plane Zones
  - All of these use NAD83 datum (or NAD83 HARN)
  - Used for the best/most standard regional representations of states
  - WI has State Plane North, Central, and South

*Image from National Geospatial-Intelligence Agency website*

# common PCS…

- Wisconsin County CRS
  - Each county in WI has its own CRS, and some county data is distributed using these.
  - You can find all of these CRS stored in projection files at this location: http://www.wisconsinview.org/research/projection_files/

# common PCS…

- WGS 84 / Pseudo Mercator
  - Aka “Web Mercator”, or in ArcMap “Web Mercator (Auxiliary Sphere)”
  - This the version of the Mercator projection that is used for Google Maps, and the vast majority of web map services
  - Most commonly used worldwide projection

# CRS Summary

- Every spatial dataset stores coordinates
- A CRS is used to correctly interpret those coordinates
- There are two basic types of CRS:
  - Geographic Coordinate Systems
    - Interprets coordinates as latitude/longitude
  - Projected Coordinate Systems
    - Interprets coordinates as x,y positions within the Cartesian plane created by a projection and origin (as defined by a central meridian and latitude of origin)
- Final detail: All CRS have their own EPSG code (a 4-6 digit number) which you may come across

# What does this mean for Quantum GIS!?

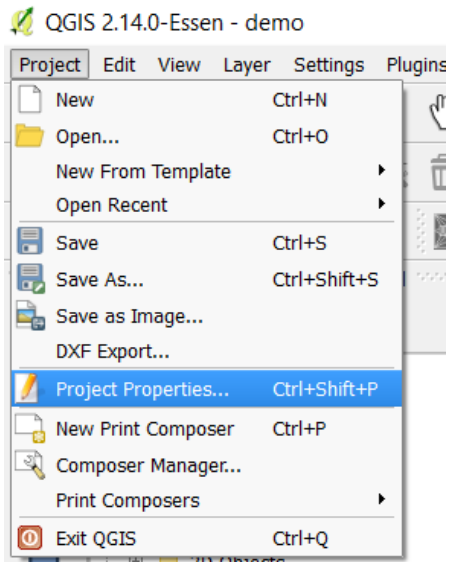
- Two different places a CRS is used:
  1. **At the Layer level**
     - Each layer must have the correct CRS defined in order for it to properly line up with all the others
       - » If your data has an embedded CRS or an accompanying .prj or .qpj file, you shouldn't need to do anything when adding it to your project.
       - » However, in many cases you'll be asked to define the CRS when you add a dataset. All you're doing is telling QGIS how to interpret your data's coordinates.
       - » Right-click a layer and select "Set Layer CRS" at any time
       - » When all layers have a correctly defined CRS, you will be happy.

# What does this mean for Quantum GIS!?

- Two different places a CRS is used:

**2: At the Project level**

- The Project CRS is the one used for the map view
  - » If you are making a map of the entire US, you would want a CRS that shows the whole thing in a pleasing way (Lambert Conformal Conic, for example)
  - » If you are making a map of southwestern Wisconsin, you may want to use State Plane WI South
  - » If you are just examining data, you may simply want to use a GCS (though things will look a little squashed)




questions and break time…